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ELECTRONIC SYSTEM WITH A SIMPLIFIED ENCLOSURE

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BACKGROUND OF THE INVENTION

[0001] Organizations that rely on information technology are highly aware that system downtime leads to lost customers, lost profit, and a soiled reputation. System availability, reliability, and serviceability define the capability of on-line enterprise to service customers and fulfill business promises.

[0002] Reliability is a fundamental aspect of availability and is attained using components and operating methods that reduce the probability of system failure, thereby increasing system availability, maintaining data integrity, and reduces or minimizes the occurrence of corrupted data. Reliability can be increased by careful design of a system and selection of system components.

[0003] Availability is the time a system is accessible and operable. Availability generally improves as a consequence of reliability advancements since the more resistant a system is to failure, the more likely the system is to remain available. Availability can also be increased by reducing failure recovery time, and increasing the accuracy of diagnosis and/or reducing repair time.

[0004] Serviceability relates to the time, effort, and cost expended in isolating and repairing a system fault and restoring the system to utility. Serviceability depends on many disparate aspects of system design including packaging, accessibility to internal system components and subassemblies, accessibility and availability of replacement components, existence and accuracy of diagnostic signals and capabilities, presence and capability of automatic diagnostic functionality, and many others.

[0005] Various techniques have been used to improve reliability, availability, and serviceability including configuration of redundant systems, enabling system upgrades such as processors, storage, input/output, and the like without interrupting a running system, support of dynamic reconfiguration, and remotely monitoring operations. Many of the techniques and design practices can add substantially to system costs.

SUMMARY

[0006] According to various embodiments, an electronic system comprises an enclosure and a backplane coupled inside the enclosure. The backplane has a plurality of slots capable of receiving a plurality of modules. The modules include power modules, cooling modules, and function modules that are capable of plug insertion into the backplane slots. The backplane receives power and signal connections from external to the enclosure via the modules rather than internal cabling.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Embodiments of the invention relating to both structure and method of operation, may best be understood by referring to the following description and accompanying drawings.

[0008] **FIGURE 1** is a pictorial block diagram that shows an embodiment of an electronic system with a simplified flexible and serviceable computer enclosure.

[0009] **FIGURE 2** is a pictorial block diagram illustrating a second embodiment of an electronic system including a simplified highly flexible and serviceable computer enclosure.

DETAILED DESCRIPTION

[0010] Referring to **FIGURE 1**, a pictorial block diagram shows an embodiment of an electronic system **100** with a simplified flexible and serviceable computer enclosure **102**. The electronic system **100** comprises the enclosure **102** and a backplane **104** in the generally form of a plane and having opposing first and second planar sides. The backplane **104** intersects the enclosure **102** and has a plurality of slots **106** on both the first and second planar sides. The slots **106** on both sides of the backplane **104** are capable of receiving multiple modules **108**. The electronic system **100** accommodates modules **108** of multiple types and functionalities. The various types of modules **108** include power modules **110**, cooling modules **112**, and various types of function modules **114**, all of which are capable of insertion into backplane slots **106**. The backplane **104** receives power and signal connections from external to the enclosure **104** via the modules **108** so that internal cabling can be omitted. In the illustrative embodiments, various types of modules **108**, other than the cooling modules **112**, have a substantially common height and depth, and are an integral number of slots wide. In some embodiments, all modules **108** use identical ejectors and are color-coded.

[0011] In some embodiments, the enclosure **102** is constructed from sheet metal and is in the form of a simple box, such as a rectangular or square box. The illustrative enclosure **102** has an airspace illustrated by airflow **116** through the enclosure **102**. The airflow **116** passes through an inlet plenum **118** at the front of the enclosure **102** and an output plenum **120** at the rear of the enclosure **102**. The illustrative enclosure **102** is arranged to accept two cooling modules **112**, one at the lower frontal area of the enclosure **102** overlying the input plenum **118**, and one at the lower rear area of the enclosure **102** overlying the output plenum **120**. The cooling modules **112** are plug insertable into the backplane **104** with one cooling module inserted into each of the respective sides of the backplane **104**. Optimum or redundant system cooling is generally attained with two cooling modules **112** utilized in a push-pull configuration with the one, typically the rear, module **112** in an inverted position. The electronic system **100** can also be used with a single cooling module **112** insertable into either of the respective sides of the backplane **104**.

[0012] The modules **108** are typically inserted in card cages that are mounted above the fans in the cooling modules **112** in both the first and second sides of the backplane **104**. Modules **108** inserted into the front and back sides of the enclosure **102** are separated by the backplane **104** that has a connector for each module slot **106**.

[0013] The electronic system **100** is easily configurable and can be configured to order by selection of a desired mix of modules **108**. The modules **108** can perform a variety of widely different functions and typically can be selected from among graphics modules, input/output (I/O) modules, Uninterrupted Power Supply (UPS) modules, storage modules, server modules, switch modules, processor modules, memory modules, and combinational modules combining functionality of a plurality of function modules.

[0014] The electronic system **100** includes one or more power modules **110** that can be plugged into slots **106** in the backplane **104**. The power module **110** has a power inlet **122** for receiving system power in a configuration for alternating current (AC) power and/or direct current (DC) power. The power modules **110** form modular configuration power supplies that are configured to enable supply of additional power and/or support a redundant power capability by addition of extra power modules **110**. Power supply modules **110** are typically, but not necessarily, located in the rear portion of the enclosure **102**.

[0015] The electronic system **100** has a simple cooling arrangement that supplies cooling for all modules **108** in the same manner. The modules **108** typically have the form of planar boards such as printed circuit cards that are mounted in a row of parallel boards inserted into the backplane **104** on the frontal and rear sides of the backplane **104**. Air flows over the card or cards in each module **108** to form an unobstructed airway between the input plenum **118** and the output plenum **120**. A frontal cooling module **112** draws air into the first plenum airspace **116** on the frontal side of the enclosure **102** and draws cooling air into the input plenum **118** and up through the modules **108** on the front side of the enclosure **102** to the airspace in the output plenum **120** within the enclosure **102** and overlying the modules **108** and the backplane **104**. The cooling airflow proceeds down through the airspaces between the modules **108** on the rear side of the enclosure to the output plenum **120** and is pulled out of the enclosure **102** by fans of the rear cooling module **112**.

[0016] In an illustrative embodiment, the rear cooling module **112** can be identical to the front cooling module **112**, although the rear module **112** is installed in an inverted arrangement in relation to the frontal cooling module **112** so that the frontal module pushes airflow into the enclosure **102** and the rear module pulls the airflow outward. A capability to use the same cooling modules **112** for both the frontal and rear enclosure locations enables versatility, and reduces the number of separate items in inventory, thereby reducing inventory management costs. Heated air removed from the rear section of the enclosure **102** is relatively distant to the air inlet on the front of the enclosure **102** so that heated air is unlikely to be drawn into the input plenum **118** and recirculated.

[0017] The illustrative electronic system **100** also has a display and control module **124** that is also plug insertable into one or more backplane slots **106**. The display and control module **124** has a user interface **126** for display and input functionality. The display and control module **124** has the height, depth, and width dimension specifications of the other modules **108**. The display and control module **124** has a display **128**, for example a liquid crystal display (LCD), light emitting diode (LED), or other status indicator. The display and control module **124** also has input keys **130** that can have functionality that ranges from menu control for the display **128** to keys for numeric and/ or alphanumeric input entry.

[0018] Some embodiments can utilize a microphone for audio entry of commands and/or data. The display and control module **124** can be configured to support biometric security capabilities. The display and control module **124** functions as an interface for a user to manage operations of the individual modules **108**. Multiple display and control modules **124** can be installed in an enclosure **102** to enhance reliability and availability by redundancy.

[0019] In an illustrative embodiment, the power modules **110** and the various types of function modules **114**, including display and control modules **124**, are capable of insertion into the same backplane slots **106**. The backplane can manage power and signal lines that carry different voltages and currents by various techniques. Typically, particular backplane pins may be reserved for connection to a particular class of lines, for example, high voltage or high current lines. In some examples, all backplane pins may be configured to manage all appropriate ranges of electric conditions.

[0020] Referring to **FIGURE 2**, a schematic pictorial diagram illustrates a second embodiment of an electronic system **200** including a simplified highly flexible and serviceable computer enclosure **202**. The electronic system **200** comprises the enclosure **202** and a backplane **204** contained within and coupled inside the enclosure **202**. The backplane **204** has multiple slots **206** capable of receiving a plurality of modules **208**. The modules include power modules **210**, cooling modules **212**, and function modules **214** that are capable of plug insertion into the backplane slots **206**.

[0021] The backplane **204**, or system circuit board, has a simple structure comprising connectors for each of the slot locations to connect signal and power lines.

[0022] The illustrative enclosure **202** contains a plenum airspace **216** including an input plenum **218** and an output plenum **220**. The plenum is a space for air circulation that is generally used for cooling of internal system components. System cooling is supplied by a cooling module **212** that is capable of plug insertion into a backplane slot **206** adjacent to the plenum airspace **216**.

[0023] In the illustrative system **200**, the various modules **208** are shown is solid and dotted lines entered into the enclosure **202** and inserted into the backplane **204**, including a power module **210** and function modules **214** that perform various operations and functions. The modules **208** generally are configured in the form of planar boards, such as printed circuit cards, so that modules **208** are inserted into the backplane **204** with cards aligned in parallel leaving space between the cards and forming an unobstructed airway that extends from the input plenum **218** and the output plenum **220**. In the illustrative system **200**, the modules **208** have a substantially common height and depth and have a variable width that corresponds to an integral number of slots **206**.

[0024] The system **200** can accommodate multiple types of function modules **214**. Common types of function modules **214** that can be used in the system **200** include graphics modules, input/output (I/O) modules, Uninterrupted Power Supply (UPS) modules, storage modules, server modules, switch modules, processor modules, memory modules, combinational modules combining functionality of multiple function modules such as compute blades with a central processing unit (CPU), memory, and input/output, and others.

[0025] One or more power modules **210** are inserted into a backplane slot **206** and have a power inlet **222** for receiving system power in a configuration for alternating current (AC) power and direct current (DC) power. In the illustrative system **200** the power module **210** has a height and depth that are substantially the same or similar to the height and depth of other function modules **208**.

[0026] The system also includes a display and control module **224** that is also plug insertable into one or more backplane slots **206**. The display and control module **224** comprises a user interface **226** including a display **228** of data and status, and an input device **230**. The display and control module **230** conforms to height and depth specifications of the other modules **208** and generally has a width that spans an integral number of slots **206**.

[0027] The illustrative systems have enhanced flexibility by virtue of the ability to customize the system by the types and numbers of modules inserted. System availability is enhanced by reduction in service time due to module service access. System maintenance costs can be reduced by enabling user serviceable modules, thereby avoid the necessity for trained personnel to service the system.

[0028] The described electronic systems and enclosures are highly versatile and can be configured to specific requirements of a particular user. For example, a configuration for computer graphics rendering may include multiple high power processor modules, multiple storage and memory modules, and multiple graphics modules. A configuration for a large database may include a very large number of storage units, a mirror data site, and redundant control and display operations.

[0029] One aspect of the illustrative electronic systems and enclosures is simplicity of interconnection between modules. In some configurations, all modules including cooling modules, power modules, display and control modules, and function modules, are plug insertable into the backplane. Accordingly, essentially all internal connections are made through the backplane. Some configurations can include no internal connections other than the backplane connections. A configuration with all modules pluggable into the backplane eliminates cable harnesses and small assemblies that can obstruct airflow and hinder system cooling, complicate the insertion and arrangement of modules, introduce

points of weakness in internal interconnections, and increase manufacturing and service costs.

[0030] Some configurations can include limited internal interconnections to status light emitting diodes (LEDs) located above the individual slots. In one example, LEDs for individual slots can be located at the top of a backplane and coupled to display apertures at the front and rear of the enclosure with optical light pipes.

[0031] In various embodiments, the system can be designed for high serviceability, reliability, and redundancy. Although a single cooling tray can be used to cool the system, a typical system has two trays, supplying a redundant cooling capability. The cooling airflow configuration is formed so that removing a single cooling fan tray for servicing does not cause an air bleed that impairs or diminishes system cooling.

[0032] Functional modules can be selected and arranged in the system to supply redundant functionality. Accordingly, high availability can be established by configurations with redundancy in all functional elements. The backplane or system circuit board is the only single point of failure. However, the backplane can be a highly simplified structure that is composed of durable and simple elements including connectors for the individual slot locations for communicating signals and power lines, and status LEDs. A simplified backplane structure enables a robust, essentially zero service subassembly. The backplane can further enhance availability in a configuration that is easily removed from the front of the enclosure in the highly rare event of servicing or failure.

[0033] The illustrative simplified, highly flexible, and serviceable computer enclosure has a simplified assembly that can eliminate internal cabling. The system can be configured with redundant cooling, power, control functions, functionality, and the like. The system is highly serviceable in many instances capable of user servicing. The system is highly configurable and can generally be easily configured to order. In many embodiments, the system is highly scalable and facilitates simple capacity increases by adding additional modules that are easily entered through front and/or back panels to the enclosure.

[0034] While the present disclosure describes various embodiments, these embodiments are to be understood as illustrative and do not limit the claim scope. Many variations, modifications, additions and improvements of the described embodiments are possible. For example, those having ordinary skill in the art will readily implement the steps necessary to provide the structures and methods disclosed herein, and will understand that the process parameters, materials, and dimensions are given by way of example only. The parameters, materials, and dimensions can be varied to achieve the desired structure as well as modifications, which are within the scope of the claims. Variations and modifications of the embodiments disclosed herein may also be made while remaining within the scope of the following claims. For example, the enclosure may be in any suitable size or shape. Various other appropriate materials may be used for any of the describe structures beyond what is described herein. The functionality and combinations of functionality of the individual modules can be any appropriate functionality.